Effect of wood fuel on SO_2 emissions in cofiring with peat and coal in fluidised bed boiler

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In Finland, indigenous sources of primary energy are hydropower, wood-based by-products of industrial processes, firewood and peat. The share of wood fuel of Finland's total fuel consumption was 20% in 1999 [1]. Grate boilers have been traditionally used for small-scale wood combustion, while FBC is most commonly used in boilers with thermal capacity greater than 5 MW. Fluidised bed combustors: bubbling FBC and circulating FBC are well suited for combined heat and power production (CHP), as their total thermal efficiency is more than twofold compared with generation power alone. By using FB techniques and biofuel cocombustion it is possible to achieve high power plant availability and combustion efficiency with low emissions. The size of fluidised bed boilers designed for solid biofuels has been successfully increased, the biggest circulating fluidised bed (CFB) boiler of 580 MW_{fuel} being under construction in Pietarsaari, Finland [2]. Strict restrictions demand increasingly stronger means of reducing sulphur emissions formed in combustion. New power plants of more than 50 MW_{fuel} have to meet the limit of 140 mg/MJ_{fuel} for SO_2 emission in Finland, and the suggested limit for SO_2 in the new EU legislation could be even $70mg/MJ_{fuel}$.

A common way to reduce SO_2 emissions in FB and CFB power plants is to use limestone as a removal sorbent. Unfortunately desulphurization by limestone increases operating and ash disposal costs. The operating cost of limestone being used for desulphurization is typically USD $1150/t_{SO2}$ in fluidised bed combustion. It has been noticed that it is possible to reduce sulphur emission by adding wood into the peat combustion process. Sulphur dioxide emissions can be reduced, as the sulphur content of wood is very low and the alkaline ash of wood can bind sulphur dioxide formed from other fuels [3, 4]. The analysis of wood and peat ashes has shown that the calcium content of both ashes is relatively high, but the compositions of the compounds in the ashes differ from each other. The calcium in wood ash is mainly in the form of carbonates, which promotes the binding of sulphur to ash. Peat calcium is mainly in the form of sulfates.

The tests with a 190 MW_{th} BFB boiler indicate that in peat combustion about 80 % of total fuel sulphur is released as gaseous flue gas emissions, as sulphur dioxide. In another comparable test conducted with a blend of 66 % wood and 34 % peat, only 55 % of total fuel sulphur was released as gaseous emissions. This indicates that interactions between wood and peat fuels and their ashes could bind roughly one third of the sulphur dioxide from peat. This is mainly due to the calcium compounds in wood that contribute to forming solid products with peat sulphur. Alkali and other alkali earth metals may also affect to some extent.

In addition to the above tests, trials have been carried out with three other boilers (290 MW_{th} BFB boiler, 330 MW_{th} CFB boiler and 84 MW_{th} CFB boiler). An appropriate amount of wood fuels: bark, saw dust, wood chips and harvesting residues, was added into the peat fuel flow. In the trials, the sulphur dioxide reduction was 17% - 30% more than that caused by an average sulphur content reduction with a fuel blend.

The total capacity of the peat-fired power plants in Finland is approximately 3000 MW_{fuel}. Supposing 20% of peat is replaced with wood fuel, the total annual SO_2 emissions could be reduced by 5% only by using wood fuels without limestone or other desulphurization methods. This reduction is mainly due to a very low sulphur content of wood fuels. About one fifth of the reduction is, however, a result of the interactions between wood ash and sulphur compounds in the fuel blend.

Also coal and bark co-combustion tests were performed with a laboratory scale CFB combustor. Three different coals were used in the tests. The objective of the tests was to find out the effect of the following factors and parameters on sulphur removal:
- percentage of bark in fuel blend
- riser temperature
- Ca/S ratio

The coal/bark blends tested contained 0, 30, 40 or 50 % of wood on an energy basis. Corresponding sulphur removals were from around 25 % (no bark) up to 60 % (50 % bark).

The riser bottom temperature had a very strong effect on sulphur removal. A sharp decrease in SO_2 emission was observed when the riser bottom temperature was decreased from 900 to 870 ?C.

Limestone was added as a sorbent in some co-combustion tests resulting in Ca/S ratios between 1 and 2. Corresponding sulphur reduction varied from 60 to 75 %, respectively. Pre-calcinated limestone was also tested.

Using experimental data of laboratory test trials multivariable PLS-model was developed to estimate SO_2 content in flue gas and to calculate the effect of wood fuel ash on sulphurdioxide emission. This model estimated quite accurately laboratory scale data and, after some small variable modifications, also data measured at a full scale CFB-boiler plant.

References

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